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## **Supplemental Material**

### **Satellite-Based Estimates of Long-Term Exposure to Fine Particles and Association with Mortality in Elderly Hong Kong Residents**

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**Figure S2.** Survival curves (Kaplan Meier) for each category of exposure to PM<sub>2.5</sub>. The y-axis indicates the survival probability along the x-axis from the baseline to years of follow-up for

groups of individuals defined by quartiles of PM<sub>2.5</sub> exposure. The differences between groups were tested by log rank test ( $p$ -value <0.001).

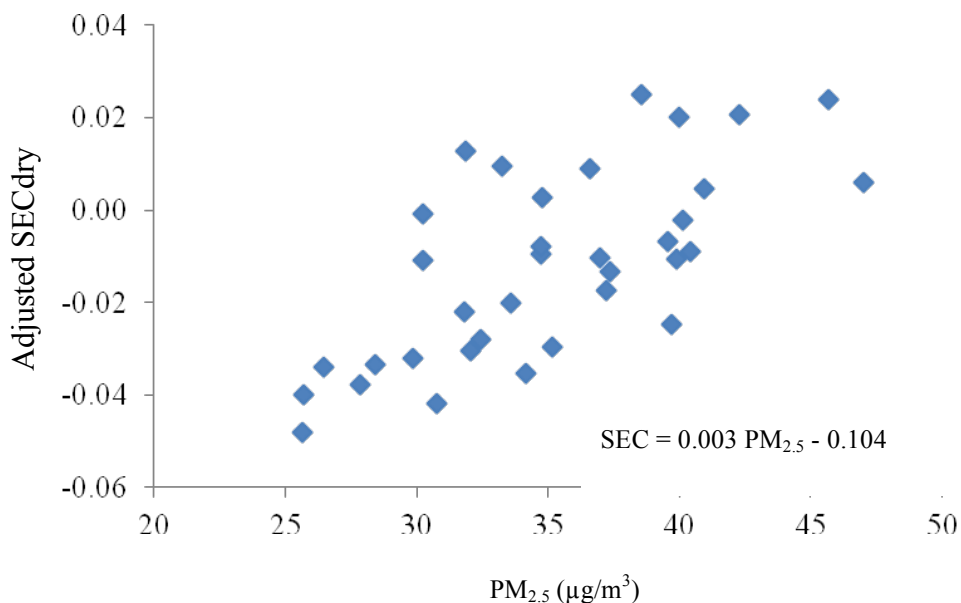
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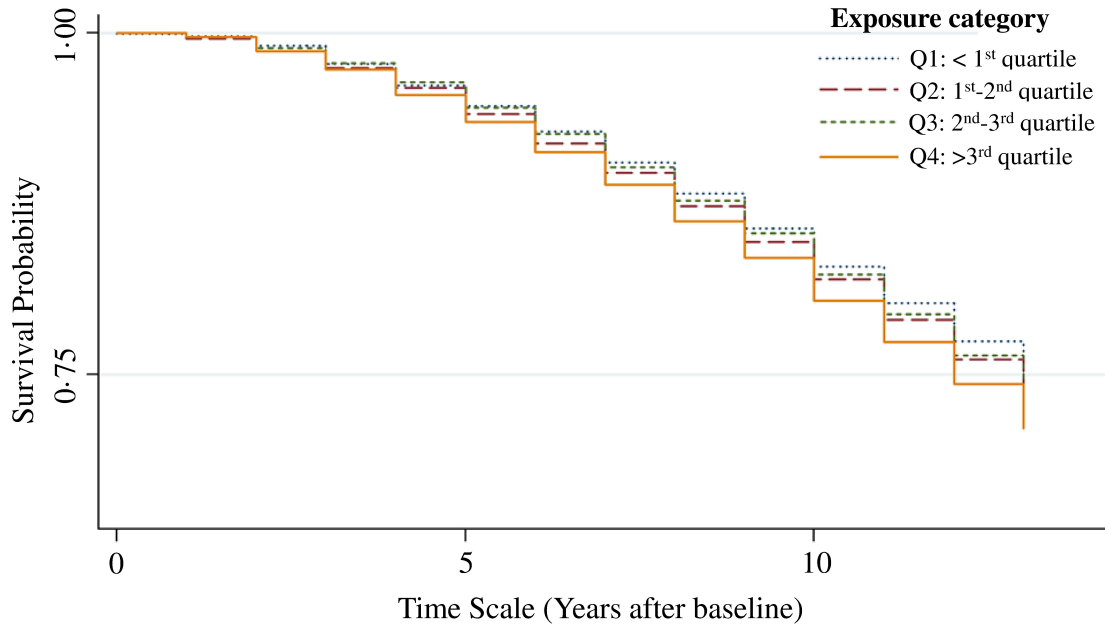
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## **Reference**



**Figure S1.** Scatterplot between annual PM<sub>2.5</sub> (4 stations) concentrations measured at general monitors and adjusted surface extinction coefficients at dry days (SECdry) (HKUST 2012) estimated at the same 1×1 km grid from NASA data year 2000–2011.  $r$  for the model = 0.60. Moderate Resolution Imaging Spectroradiometer (MODIS) data (<http://modis.gsfc.nasa.gov/about/components.php>) from two satellites, Terra (EOS AM) and Aqua (EOS PM) (<http://modis.gsfc.nasa.gov/about/>), were applied for correlation with aerosols and atmospheric optical conditions ([http://disc.sci.gsfc.nasa.gov/giovanni/additional/users-manual/G3\\_manual\\_Chapter\\_8\\_MOVAS.shtml#What](http://disc.sci.gsfc.nasa.gov/giovanni/additional/users-manual/G3_manual_Chapter_8_MOVAS.shtml#What)). Lidar measurement was used for estimating surface extinction coefficients (SEC) from aerosol optical depth (AOD), over non-reflective urban surface. SEC (unit: km<sup>-1</sup>) was controlled for humid and rainy day and stored as “SEC dry” data by the meteorological research team of the Institute of the Environment, The Hong Kong University of Science and Technology (<http://envf.ust.hk/itf-si/>).



**Figure S2.** Survival curves (Kaplan Meier) for each category of exposure to PM<sub>2.5</sub>. The y-axis indicates the survival probability along the x-axis from the baseline to years of follow-up for groups of individuals defined by quartiles of PM<sub>2.5</sub> exposure. The differences between groups were tested by log rank test ( $p$ -value <0.001).

**Table S1.** Hazard ratio (95% CI) of mortality from all natural causes adjusted for individual covariates only and together with ecological covariates measured at baseline 1998–2001.

| <b>Variables</b>   | <b>Individual covariates</b> | <b>Individual and ecological covariates</b> |
|--|------------------------------|---|
| Individual level:  |                              |   |
| PM <sub>2.5</sub> concentration (per 10 µg/m <sup>3</sup> )  | 1.13 (1.06, 1.21)***         | 1.14 (1.07, 1.22)***                        |
| Age (per year)   | 1.11 (1.11, 1.12)***         | 1.11 (1.11, 1.12)***                        |
| Gender: Male   | 1                            | 1   |
| Female   | 0.65 (0.63, 0.68)***         | 0.65 (0.63, 0.68)***                        |
| BMI quartiles: 2 <sup>nd</sup> – 3 <sup>rd</sup> (21.6–26.3) | 1                            | 1   |
| <2 <sup>nd</sup> (<21.6)                                     | 1.25 (1.21, 1.30)***         | 1.25 (1.21, 1.30)***                        |
| >3 <sup>rd</sup> (>26.3)                                     | 1.03 (0.99, 1.07)            | 1.02 (0.98, 1.06)                           |
| Smoking: Never   | 1                            | 1   |
| Quitted  | 1.39 (1.33, 1.45)***         | 1.38 (1.32, 1.43)***                        |
| Current  | 1.73 (1.64, 1.81)***         | 1.70 (1.62, 1.79)***                        |
| Exercise (days per week)                                     | 0.97 (0.96, 0.98)***         | 0.97 (0.95, 0.98)***                        |
| Education: Secondary or above                                | 1                            | 1   |
| Primary  | 1.11 (1.06, 1.16)***         | 1.09 (1.04, 1.14)***                        |
| Below primary  | 1.23 (1.17, 1.29)***         | 1.19 (1.13, 1.25)***                        |
| Expense per month (US\$) <128                                | 1.08 (1.02, 1.14)**          | 1.08 (1.02, 1.14)**                         |
| 128–384  | 1.03 (0.99, 1.08)            | 1.03 (0.98, 1.07)                           |
| ≥385   | 1                            | 1   |
| TPU level:   |                              |   |
| Age≥65 (per %)   | -                            | 0.99 (0.98, 0.99)***                        |
| Education at tertiary level (per %)                          | -                            | 0.99 (0.99, 1.00)***                        |
| Income/month ≥US\$1,923 (per %)                              | -                            | 1.00 (1.00, 1.00) <sup>a</sup>              |
| District level:  |                              |   |
| Smoking rate [as % of smokers] (per %)                       | -                            | 1.06 (0.99, 1.14)                           |

\*p<0.05, \*\*p<0.01, \*\*\*p<0.001.

Crude HR per 10 µg/m<sup>3</sup> PM<sub>2.5</sub> concentration: 1.23 (1.16, 1.31) p<0.0001.

<sup>a</sup>The same HR (95%CI) but with three decimal points: 0.999 (0.996, 1.001).

**Table S2.** Hazard ratio of mortality per 10  $\mu\text{g}/\text{m}^3$  increase in  $\text{PM}_{2.5}$  – stratified by education attainment

| <b>Education attainment</b> | <b>N</b> | <b>All natural causes</b> | <b>Interaction p-value</b> | <b>Cardio-respiratory</b> | <b>Interaction p-value</b> |
|-----------------------------|----------|---------------------------|----------------------------|---------------------------|----------------------------|
| Secondary or above          | 10411    | 1.09(0.92,1.30)           |                            | 1.09(0.84,1.41)           |                            |
| Primary                     | 22370    | 1.14(1.02,1.27)*          | 1.00                       | 1.09(0.93,1.28)           | 0.75                       |
| Below primary               | 27446    | 1.17(1.06,1.29)**         | 0.46                       | 1.23(1.07,1.42)**         | 0.36                       |

\*p<0.05, \*\*p<0.01.

**Table S3.** Hazard ratio of mortality per 10  $\mu\text{g}/\text{m}^3$  increase in  $\text{PM}_{2.5}$  – multi-level analyses.

| <b>Causes of death</b> | <b>Individual level</b> | <b>Multi-level analysis<br/>District + TPU</b> | <b>Multi-level analysis<br/>District + TPU +<br/>subject ID</b> |
|------------------------|-------------------------|--|---|
| All natural causes     | 1.14(1.07,1.22)***      | 1.14(1.07,1.22)***                             | 1.14(1.07,1.22)***  |
| Cardiovascular         | 1.21(1.07,1.37)**       | 1.21(1.07,1.38)**                              | 1.21(1.07,1.38)**   |
| - IHD                  | 1.41(1.16,1.71)***      | 1.40(1.14,1.71)***                             | 1.40(1.14,1.72)***  |
| - Cerebrovascular      | 1.22(0.99,1.50)         | 1.23(1.00,1.52)                                | 1.24(1.00,1.53)   |
| Respiratory            | 1.04(0.89,1.21)         | 1.04(0.88,1.21)                                | 1.05(0.89,1.23)   |
| - Pneumonia            | 0.94(0.77,1.13)         | 0.93(0.76,1.13)                                | 0.93(0.76,1.14)   |
| - COPD                 | 1.29(0.98,1.70)         | 1.29(0.96,1.71)                                | 1.34(0.99,1.79)   |

R software was used for the analysis; \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$

**Table S4.** Hazard ratio of mortality per 10  $\mu\text{g}/\text{m}^3$  increase of  $\text{PM}_{2.5}$  – adjustment for spatial autocorrelation.

| Causes of death    | No random effect   | One-Level random effect in TPU, Distance-matrix (adjacency) | One-Level random effect in TPU, Distance-matrix (distance-decay in km) | Two-Level random effect in District and TPU, Distance-matrix (Distance decay within TPU) |
|--------------------|--------------------|---|--|--|
| All natural causes | 1.14(1.07,1.22)*** | 1.14(1.07,1.22)***  | 1.14(1.07,1.22)***   | 1.14(1.07,1.22)***   |
| Cardiovascular     | 1.22(1.08,1.39)**  | 1.21(1.07,1.37)**   | 1.21(1.07,1.37)**  | 1.20(1.06,1.37)**  |
| - IHD              | 1.42(1.16,1.73)*** | 1.40(1.15,1.71)***  | 1.41(1.16,1.71)***   | 1.43(1.17,1.75)***   |
| - Cerebrovascular  | 1.24(1.00,1.53)    | 1.22(0.99,1.50)   | 1.22(0.99,1.50)  | 1.24(1.00,1.53)  |
| Respiratory        | 1.05(0.90,1.22)    | 1.04(0.89,1.21)   | 1.04(0.89,1.21)  | 1.05(0.90,1.23)  |
| - Pneumonia        | 0.94(0.77,1.14)    | 0.93(0.77,1.13)   | 0.94(0.77,1.13)  | 0.94(0.77,1.15)  |
| - COPD             | 1.30(0.98,1.74)    | 1.28(0.96,1.69)   | 1.28(0.96,1.68)  | 1.31(0.98,1.75)  |

R software was used for the analysis, the models were not adjusted for district level smoking rate.

\* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$



## **Reference**

Hong Kong University of Science and Technology (HKUST) 2012. Satellite Informatics System for Surface Particulate Matter Distribution. Institute of the Environment. Available: <http://envf.ust.hk/itf-si> [accessed 27 March 2015].